**Predicting Hospital Length of Stay**

**Introduction**

* Reducing healthcare costs is of primary concern

http://www.nejm.org/doi/full/10.1056/NEJMp1612517

* Rising healthcare costs in the states (source)

http://www.nejm.org/doi/full/10.1056/NEJMp1612517

* debate on changing healthcare system (source)

<http://www.nejm.org/doi/full/10.1056/NEJMsb1612292#t=article>

<http://www.nejm.org/doi/full/10.1056/NEJMp1713346>

<http://www.nejm.org/doi/full/10.1056/NEJMp1714824>

* reducing costs increases funds for treatment (source)

<https://www.ncbi.nlm.nih.gov/pubmed/10945354>

<https://www.ncbi.nlm.nih.gov/pubmed/11020394>

* To change costs, need to improve management
* Patient length of stay in a hospital is directly associated with cost (source)
* Good Health Corporation has collected data on 3612 patients admitted into the hospital including Length of Stay and other possible predictors

<http://ieeexplore.ieee.org/document/6406418/>

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1067345/>

* To better understand the factors that affect LoS so that these can be addressed and optimized to reduce healthcare costs, we created a predictive model using multiple linear regression, based on the GHC data, that predicts patient length of stay based on relevant predictor variables

**Methods**

**Data Source**

* GHC collected a total of 3682 visit records on 3612 patients who were admitted to the hospital and over the age of 17. The visit had to have occurred within 24 hours of hospital admission. Data collected for each visit included: length of stay in the hospital (days), modified early warning score (MEWS), the Charlson Comorbidity Index rank, if the patient had an ICU visit during hospitalization, the number of ER visits in the previous 6 months, insurance type, patient demographics, and patient vital signs.

**Data Processing and Cleaning**

* If a patient had more than one visit, only the first visit was included for model building. Due to skew and nonnormality of the Length of Stay outcome variable, Length of Stay was natural logarithm transformed. For all predictors, values outside of the 95percent confidence interval predicted values for the means were replaced by the mean values as they were unrealistic and clearly errors (e.g. heartrate of 37). For model building only relevant predictors were included: 30 day readmit rate, ER visits in past 6 months, Charson Index rank, MEWS, ICU flag, demographics (age, race, marital status), insurance type and vital signs (respiration rate, O2 saturation, BMI, Heartrate, Temperature, diastolic blood pressure and systolic blood pressure). We decided to omit data on religion due to lack of relevance. Predictor values were screened for outliers and outliers were removed prior to model selection.

**Model Selection**

* Using our selected predictors, we utilized both stepwise regression selection and criterion based automatic procedures to select the best multiple linear regression model. The final model with the highest adjusted R2 value and lowest CP value was selected.

**Model Diagnostics**

* Model assumptions were checked. A residuals vs fitted value plot was created to detect for error heteroscedasticity. A quantile-quantile plot was created to detect normality of residuals. A scale-location plot was created to detect residual spread. A residuals versus leverage plot was created to help identify influential cases. Outliers in the length of stay were screened for using studentized residuals. Leverage values in predictors were screened for as were influential predictors. Finally, multicollinearity was also screened for using VIF values and the findings were not significant.

**Model Validation**

We validated our final model using a Bootstrap method.

**Results:**

**Data Summary**

* Comment on Length of stay
* Comment on patient demographics, insurance type

**Fitted Model**

* The final model included: 30 day readmit rate, ER visits, C Index, Age, Respiration Rate, Heart Rate, Systolic Blood pressure
* Values associated with model
* Plot of model is here
* Comment of diagnostic plots
* Outliers results
* Comment on bootstrap validation. Model bias as found by bootstrap was quite small with the highest bias being X.

**Discussion**

* Model is minimally predictive, low R2
* Possibly better to use different modelling technique such as quadratic fit or something else
* Comment on included predictors in the final model

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variable n mean sd minimum maximum median

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losdays2 3612 5.461 5.92 0.04167 87.96 3.833

ageyear 3612 65.69 18.69 18 105 68

evisit 3612 1.754 1.577 0 4 1

bmi 2929 28.35 7.991 3.1 122.7 27.1

bpsystolic 3607 130.6 16.72 88.78 194 129.2

o2sat 3609 97.86 4.908 80 236.5 97.59

temperature 3610 36.73 0.899 11.85 52.27 36.73

heartrate 3607 80.07 13 37.58 242.6 79.2

respirationrate 3609 18.2 2.633 12 67.72 17.76

bpdiastolic 3611 72.52 9.798 29.56 154.4 71.85

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|  |  |
| --- | --- |
| Variable | N (%) |
| **Gender** | |
| Male | 1660 |
| Female | 1952 |
| **Race** | |
| White | 2057 |
| Black | 772 |
| Asian | 249 |
| Native American (Alaskan) | 22 |
| Native American (Hawaiian/Pacific Islander) | 4 |
| Other | 508 |
| **Insurance** | |
| Medicare | 1425 |
| Medicaid | 166 |
| Private | 1987 |
| Missing Data | 34 |
| **Marital Status** | |
| Single | 951 |
| Married | 1607 |
| Widowed | 690 |
| Divorced | 235 |
| Separated | 51 |
| Civil Union | 1 |
| Missing Data | 77 |
| 30 Day Readmit Rate | 517 |

> sum(hos\_tidy$is30dayreadmit)

[1] 517

> sum(hos\_dummies$gender)

[1] 1660

> sum(hos\_dummies$white=='1')

[1] 2057

> sum(hos\_dummies$black=='1')

[1] 772

> sum(hos\_dummies$asian=='1')

[1] 249

> sum(hos\_dummies$natv\_amer\_alaskan=='1')

[1] 22

> sum(hos\_dummies$natv\_hawaii\_pacf\_isl=='1')

[1] 4

> sum(hos\_dummies$medicare=='1')

[1] NA

> sum(na.omit(hos\_dummies$medicare=='1'))

[1] 1425

> sum(na.omit(hos\_dummies$medicaid=='1'))

[1] 166

> sum(na.omit(hos\_dummies$private=='1'))

[1] 1987

> sum(hos\_dummies$single=='1')

[1] NA

> sum(na.omit(hos\_dummies$single=='1'))

[1] 951

> sum(na.omit(hos\_dummies$married=='1'))

[1] 1607

> sum(na.omit(hos\_dummies$widowed=='1'))

[1] 690

> sum(na.omit(hos\_dummies$divorced=='1'))

[1] 235

> sum(na.omit(hos\_dummies$separated=='1'))

[1] 51

> sum(na.omit(hos\_dummies$civil\_union=='1'))

[1] 1

> sum(is.na(hos\_dummies$married))

[1] 77

> sum(is.na(hos\_dummies$medicare))

[1] 34

3612